

Remote Control and Monitoring of Solar Powered Robotic Automation Vehicle using LabVIEW

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Abstract: This paper illustrates the control of a solar powered robotic vehicle from a remote control room using LabVIEW and ANYPLACE CONTROL software. Passive infrared sensors are used for obstacle detection and for safety. This finds applications in various fields like transportation of patients from one block to another in a hospital, touring of the university campus, site seeing in a safari, in malls and in the military.

Keywords: LabVIEW, ANYPLACE CONTROL, robotic vehicle, DC motor.

1. INTRODUCTION

In this era of rapid technological advancements, efficient ways of reducing human work load are being designed. An automated robotic vehicle is one such revolution. Without human interference, even laborious activities can be performed with the help of a robot efficaciously.

A robotic automation vehicle is an approach which requires minimum human effort. This vehicle is used to ferry people and goods from one place to another. For safety, sensors are used for obstacle detection.

The robotic vehicle runs on a DC shunt motor which has excellent speed control. Its speed can be varied in two ways. These include varying the amount of current supplied to the shunt fields and controlling the amount of current supplied to the armature. Controlling the current to the shunt field allows the rpm to be changed 10-20% when the motor is at full load.

There are various methods of speed control of a DC shunt motor such as flux control, armature control and voltage control. The speed of the DC motor in this vehicle is controlled by varying the armature voltage using the Pulse Width Modulation (PWM) technique.

Section II gives an overview of the system design.

2. SYSTEM DESCRIPTION

The prototype of this robotic vehicle consists of a laptop (ANY PLACE CONTROL) in the control room and a tablet (ANY PLACE CONTROL and LabVIEW), a DC shunt motor, solar panel, battery, Data acquisition (DAQ) in the robotic vehicle as shown in Figure 1.

The remote operation of the robotic vehicle is done from the control room, where a laptop with ANYPLACE CONTROL software is installed. It enables screen sharing and file transfer between two computers, both equipped with the software. The tablet with LabVIEW and ANYPLACE CONTROL is installed in the vehicle. The screen of this tablet is accessible to the laptop in the control room. By using NI LabVIEW as the motor controller, we can control a DC motor for multiple purposes using only one

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software environment. With the push of a button in LabVIEW, a DC motor can start, stop, and rotate in any desired direction.

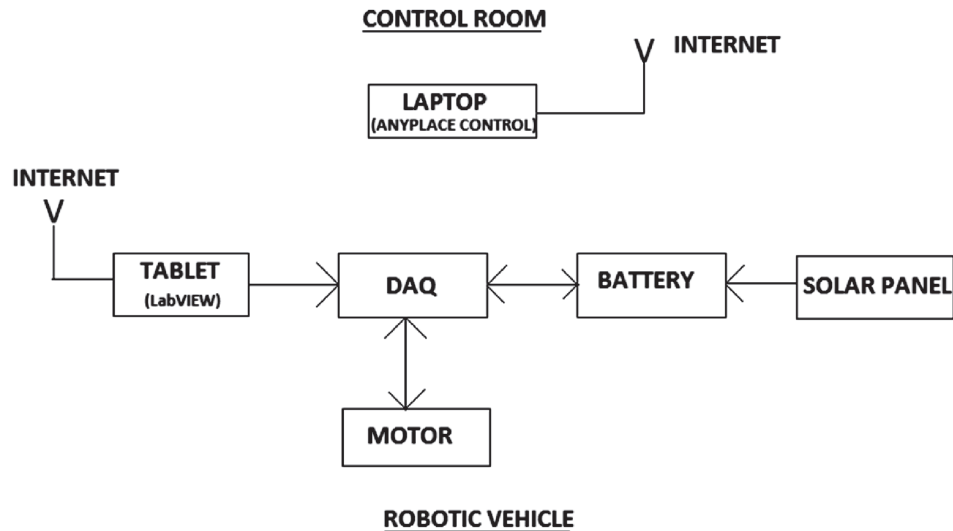


Figure 1: Schematic Diagram

The DC motor and the tablet in the vehicle are interfaced via the DAQ. The ON/OFF operation and speed control of the vehicle is carried out by the DC Shunt motor which is operated by the laptop in the control room. The motor gets its supply from a solar powered battery. Under direct sunlight, the solar panel generates up to 6V of electricity with maximum current up to 270mA. The panel is enough to provide power to the motor under direct sunlight; however a battery has to be installed since the rotor needs a slight push to start.

3. SYSTEM DESIGN

This system is designed for a prototype where we have a DC shunt motor which is capable of carrying a load equivalent to the weight of four people. This robotic vehicle follows the point to point shuttle mode and moves in a straight track assigned to it. Passive infrared sensors are used for obstacle detection. The battery for the motor is powered by a solar panel of appropriate dimension, which is fitted to the top of the vehicle to prevent frequent charging of the battery. A DAQ is used as an interface between the hardware (motor, battery, solar panel) and the software (LabVIEW). This facilitates easy operation (speed control and on-off operation) from the control room (remote location).

4. MATHEMATICAL MODELLING

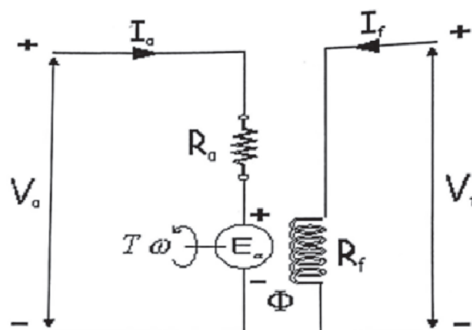


Figure 2: Circuit for mathematical modeling

The instantaneous value of armature (terminal) voltage $v(t)$ is defined as:

$$V_a(t) = R_a i_a(t) + L_a di_a(t)/dt + e_a(t) \quad (1)$$

Where R_a is the armature resistance, L_a is the armature inductance, $i_a(t)$ is the instantaneous armature current and $e_a(t)$ is the armature back emf.

The armature back emf $e_a(t)$ is expressed as:

$$e_a(t) = K\phi\omega \quad (2)$$

Where K is the motor constant, ϕ is the magnetic flux and ω is the angular rotational speed.

The developed torque T is defined by:

$$T = K\phi i_a(t) \quad (3)$$

Neglecting the friction in the system, the equation of motion will be:

$$T - T_L = Jd\omega/dt \quad (4)$$

Where T_L is the load torque and J is the equivalent moment of inertia of the system.

For steady-state ($d/dt = 0$) operation, the following two equations can be obtained:

$$\omega = (V_a/K\Phi) - (I_a R_a/K\Phi) \quad (5)$$

$$\omega = (V_a/K\Phi) - (TR_a/(K\Phi)^2) \quad (6)$$

Where V_a and I_a are the steady-state values of armature voltage and armature current, respectively.

Equation (5) is called electromechanical characteristic of the drive system and equation (6) is called torque/speed (mechanical) characteristic of the drive system.

The first term in Equations (5) and (6) represents the no-load speed ω_o of the drive system and the second term represents the drop in speed $\Delta\omega$ due to the load.

The relationship:

$$\beta = dT/d\omega = \Delta T/\Delta\omega \quad (7)$$

Is called the hardness or mechanical characteristic of the drive system, which represents the sensitivity of the system to the change in load torque.

$$\begin{aligned} q &= (T_{ON}/(T_{ON} + T_{OFF})) 100\% \\ &= (T_{on}/T_{cyc}) 100\% \end{aligned} \quad (8)$$

Where T_{on} is the duty (turned-on) interval, T_{off} is the turned-off period, and T_{CYC} is the cycle time (period).

The average value of the voltage applied to the armature V_a equals:

$$V_a = 1/T_{CYC} \int V dt \quad (t \rightarrow 0 \text{ to } T_{ON})$$

Thus,

$$V_a = qV \quad (9)$$

The equations for electromechanical and mechanical characteristic can be written as:

$$\omega = (qV/K\Phi) - (I_a R_a/K\Phi) \quad (10)$$

$$\omega = (qV/K\Phi) - (TR_a/(K\Phi)^2) \quad (11)$$

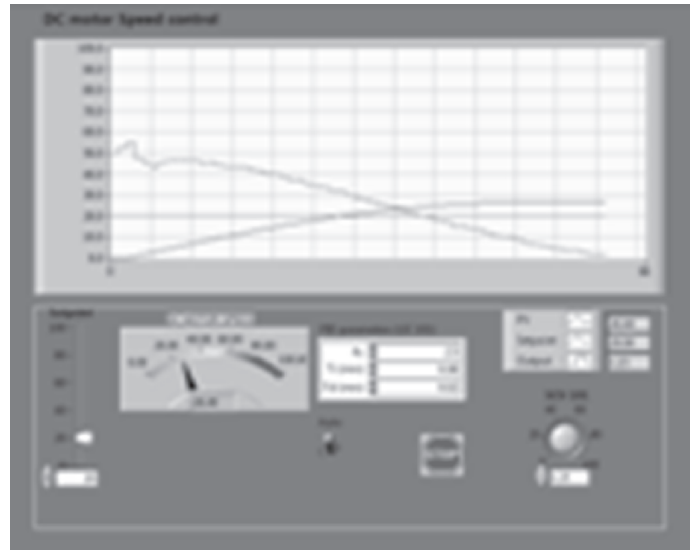


Figure 4: Simulation before set point is achieved

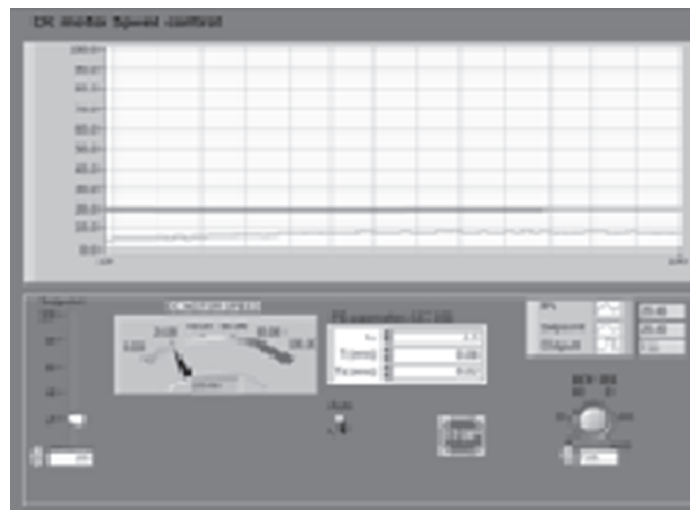


Figure 5: Simulation after set point is achieved

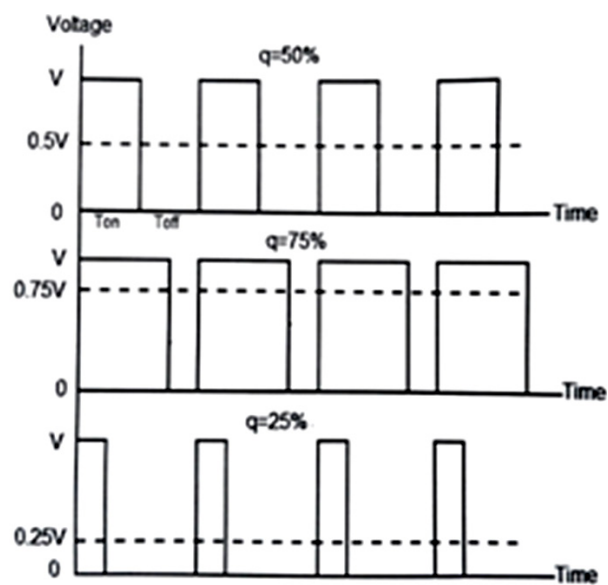


Figure 6: Pulse with modulation

Figure 6 represents the armature voltage control by pulse width modulation technique. In the first graph $T_{on} = T$ (duty cycle = 50%) which shows that motor speed approaches the set point. $T_{on} = 3/4T$ ($q = 75\%$) in the second graph where the speed increases continuously above the set point. The third graph indicates $T_{on} = 1/4T$ ($q = 25\%$), which implies that speed decreases below the set point.

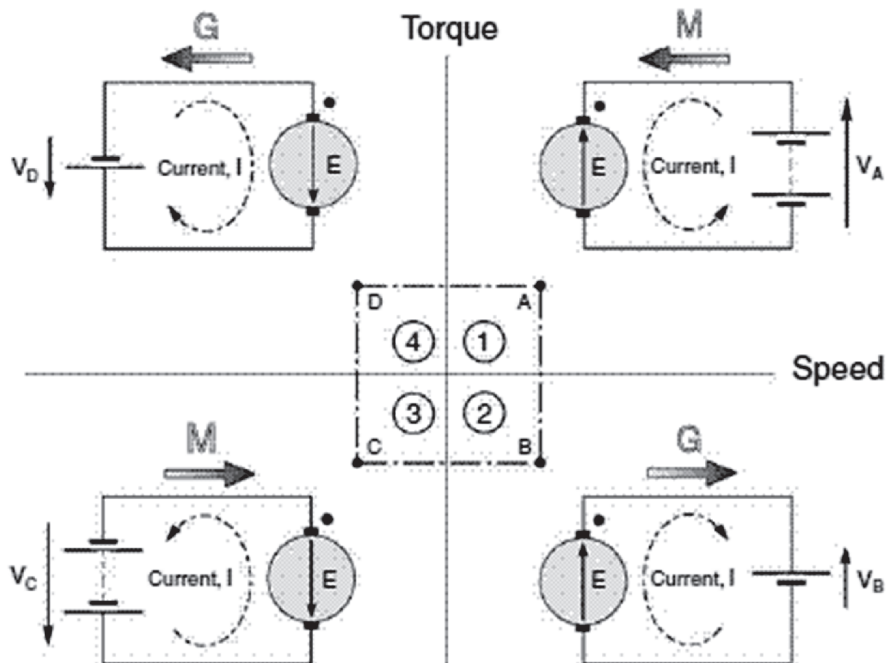


Figure 7: Four quadrant operation

Figure 7 represents the four quadrant operation of the motor. The robotic vehicle can be controlled in these modes.

6. CONCLUSION

This paper gives an outline for an efficient robotic automated vehicle which can be used as a point to point passenger ferry. It has two advantages; the first being that it does not require a driver to operate the vehicle, thereby saving on manpower and time. The second is that it can be controlled from any remote location as long as the two softwares are present. Also it is an eco friendly design as the battery is solar powered which results in no pollution of any sorts. If this system design is scaled up to meet the actual requirements of a working model it can prove to be very efficient and save a lot of time and human effort. This vehicle can find applications in hospitals, touring of a university campus, general site seeing and also in military camps.

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